There are a few chapters setting out broad and promising new fields of research (for example, Montagna and his co-workers on pigment cells in primates) and others (for example, Hadley and Quevedo on physiological and morphological colour change) describing rounded and meaningful biological researches. These papers present stimulating ideas as well as hard facts and they are in the tradition of 1948; but they are a minority. Too many of the other chapters are little more than detailed accounts of recent additions to chemical and ultrastructural knowledge about pigment cells and of the technical methods by which they have been obtained. Since much of this has already appeared in journals (and what has not will do so), one wonders if it is necessary to reproduce it at such length in a book of this kind. A smaller and more interesting book could have been made with the minority group of papers as its main substance. An appendix containing the findings and conclusions of the technical papers, in the form of fully referenced abstracts, would have provided adequate information for the general reader.

In the coda to the opening chapter is the remarkable statement that "the melanocyte is as well understood as any mammalian cell". We may have an unrivalled quantity of factual knowledge about its chemistry and ultrastructure but, as is made abundantly clear by some of the other chapters, we cannot yet claim much understanding of its biology. Tennis is a game played with racquets; but complete knowledge of the molecular structure of a tennis racquet would not confer understanding of the game. Biology is concerned with a game called life; but knowing about biochemicals and understanding biology are not quite the same thing.

Judging from this book, the soul has begun to go out of pigment-cell research. Some will hail this as the dawning of a more advanced scientific era for the subject; others will deplore it as the passing of a golden age and the beginning of an extravagant period of decadence. Anyone who reads the whole of this book and is familiar with its ancestor of 1948 will know which view he takes.

I. W. WHIMSTER

[1] *The Biology of Melanomas* (edit. by Miner and Gordon) (NY Academy of Sciences, Special Publications, 1948).

SMALL LEARNING AND LESS CHEMISTRY

Chemistry of Learning

Invertebrate Research. (Proceedings of a Symposium sponsored by the American Institute of Biological Sciences, held at Michigan State University, September 7–10, 1966.) Edited by W. C. Corning and S. C. Ratner. Pp. xii + 468. (New York: Plenum Press, 1967.) n.p.

THE brain consists of chemical substances; living organisms are inherently chemical; there will therefore be chemical aspects to learning. Of such as are now known, this book reveals little. Its title is misleading. On cover and spine appears only *Chemistry of Learning*. On its title-page comes the smaller-type qualification *Invertebrate Research*. Only in the second paragraph of its preface is the reader told that the greater part of the book is given to "planarian research". Some of the free-living flatworms of the phylum Platyhelminthes have been used in work which aimed at investigating learning, and part of the present book makes more understandable the shortcomings of these experiments; it does not recount the "chemistry of learning".

Of the book's twenty-seven chapters, the seven longest occupy about half the text and concern morphogenesis, neuroanatomy and behavioural studies, mainly in planarians and in hydra. Notable characteristics of some species of planarians are their ability to undergo asexual reproduction and a remarkable degree of regeneration after damage or bisection, for example, re-forming a complete animal after decapitation. The nature of the nervous system of *Dugesia dortocephala*, which can regenerate in this way, has been the subject of fresh neuroanatomical studies well described by J. B. Best. These studies, using electron microscopy, have shown well-characterized nerve terminals and synaptic connexions, with synaptic cleft and adjacent thickenings and with aggregations of synaptic vesicles at their presynaptic side. Neurosecretory granules, multivesicular bodies and neurotubules are also in evidence, together with a richness of fine fibre connexions; accessory cells akin to neuroglia are also reported. In comparison with higher animals, "all the basic parts seem to be there", although they are miniaturized and less numerous than in the vertebrate brain; chemical information is not as yet available to accompany this account. The presumed neurosecretory granules, or their secretion, are given no chemical identity. Chemically characterized factors in morphogenesis would also be relevant to the book's title, but do not feature.

A reader persistent in seeking information on chemistry of learning reaches on page 310 the chapter entitled "The Biochemistry of Memory". Here is given an anecdotal account of experiments with planarians, modified in behaviour by exposure to light and electroshock. The modification in behaviour was retained under certain conditions of regeneration. Possibly, also, disrupted (but not finely ground) preparations from the planarians modified in behaviour, when fed to other planarians, altered their behaviour in a fashion related to the changes induced by light and electroshock. At this point, where quantitative descriptions of chemical fractionation and of the biological test-systems used to test these specific fractions are most needed, little or none is given. The reader is not told of chemical characterization and identification but of a suggestion that "one of the nucleic acids, probably RNA, might be the memory molecule", and that "ribonuclease seemed to wipe out the memory". Is it pedantic to comment that chemistry and biochemistry are disciplines of scientific thought and experimentation, and not slogans?

There is much of value in the individual contributions to this book by its twenty-six authors or co-authors. D. M. Vowles makes excellent use of brain lesions and changed sensory input in understanding visual discrimination and behaviour in the wood ant, *Formica rufa*. M. M. Jenkins's account of planarian behaviour indicates both its regularities and its fascinating unpredictability. Reactions of hydra to glutathione and its analogues, and the uptake of some organic compounds by planarians, are also described. But the significance of many contributions has been blurred by the book's titling and presentation. *The* chemistry . . ., *the* biochemistry . . ., *the* molecule . . . have raised expectation falsely high and degraded the book's subject. In Joyce's strange but apposite phrase, we see a pier as a disappointed bridge. Contributing also to this clouding is the omission of much which is satisfactory in chemical approaches to behavioural studies, to learning or to memory; in particular, of work which has been carried out using higher animals.

H. MCILWAIN

NUFFIELD CHEMISTRY

Nuffield Foundation Handbook for Teachers

Pp. 415. Published for the Nuffield Foundation by Longmans/Penguin Books; Longmans Green and Co., Ltd. 27*s*. 6*d*.

THIS book is intended to fill in the theoretical background to the Nuffield O-level chemistry course, explaining why it was necessary to alter the methods of teaching chemistry that have been used in the past, and showing in detail what ideas and principles dictated the form and substance of the *Sample Scheme* published in 1966. Many

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